# INTT progress in Taiwan

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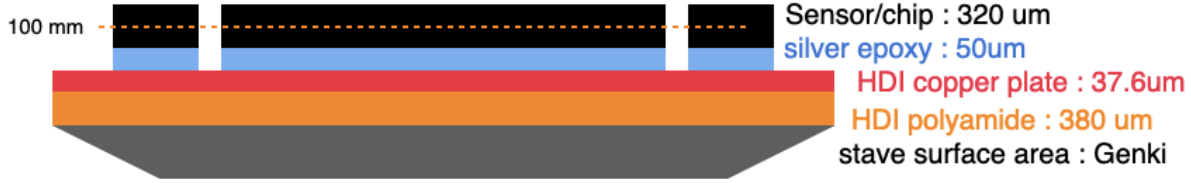
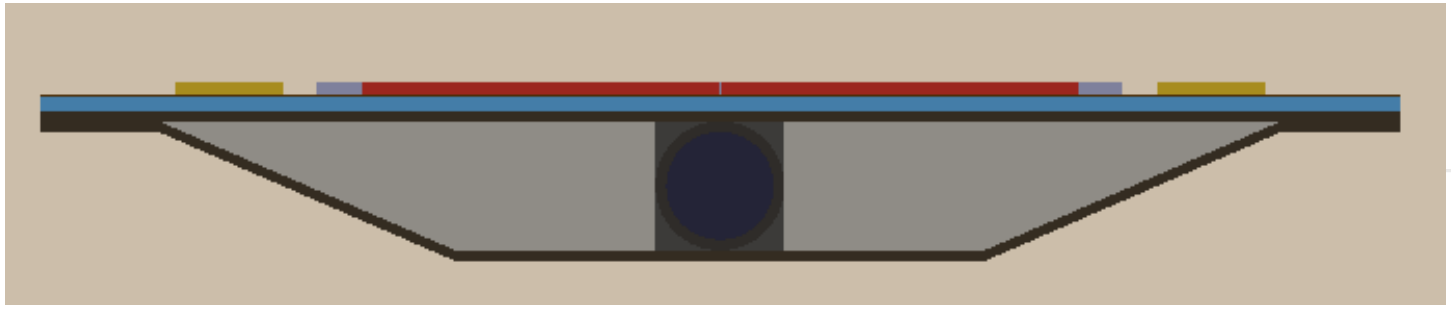
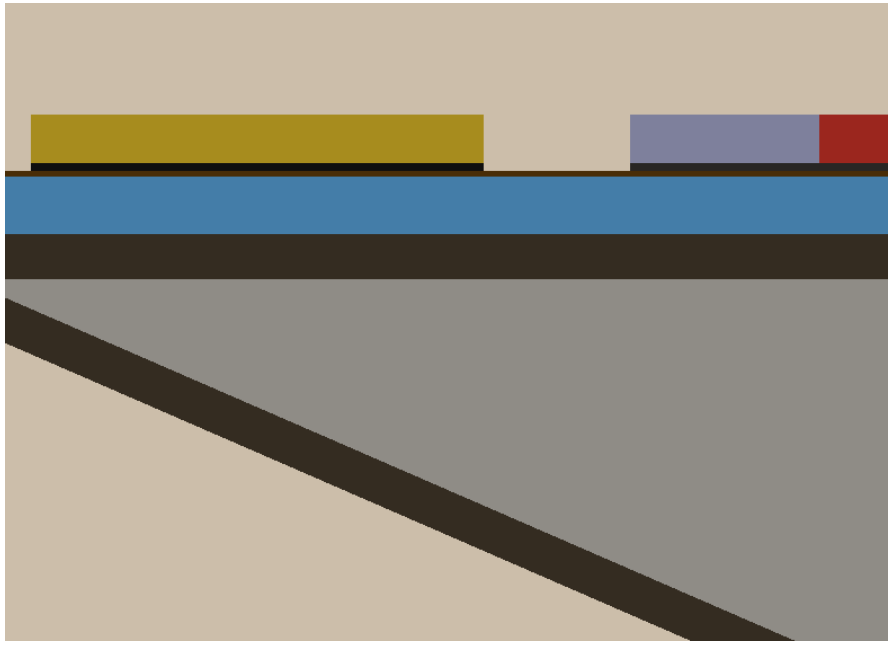
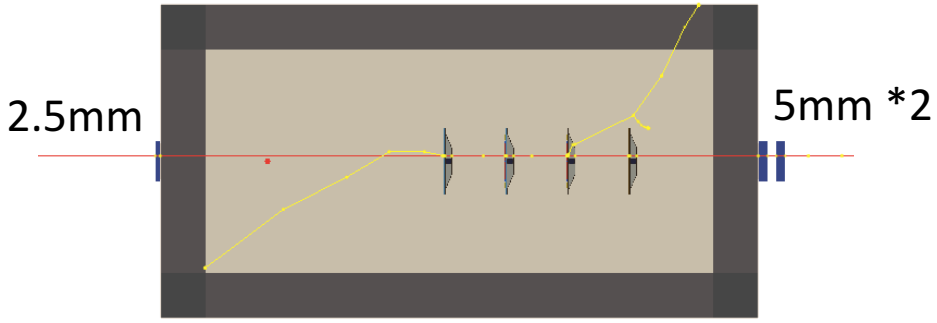
# G4 update

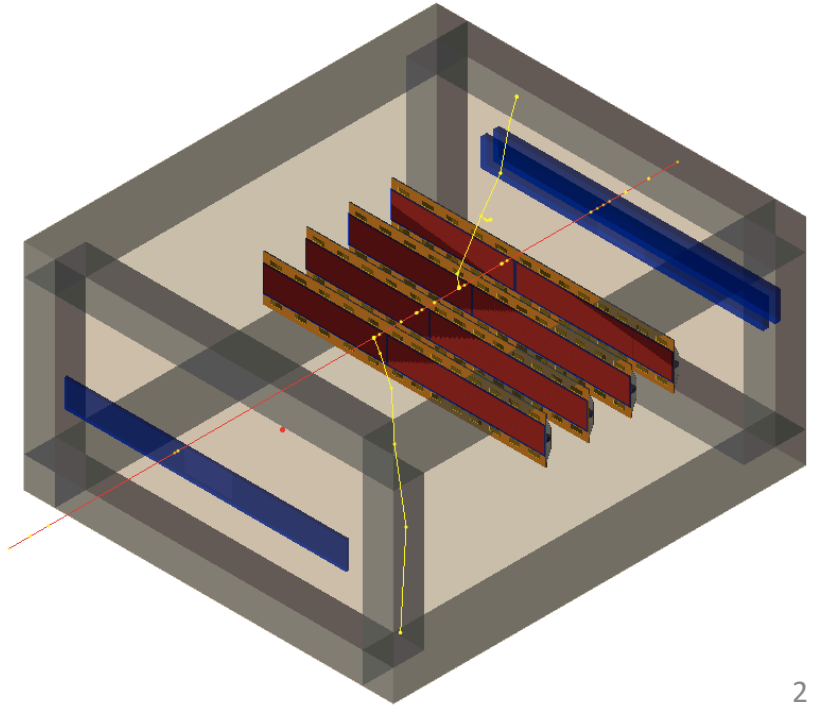


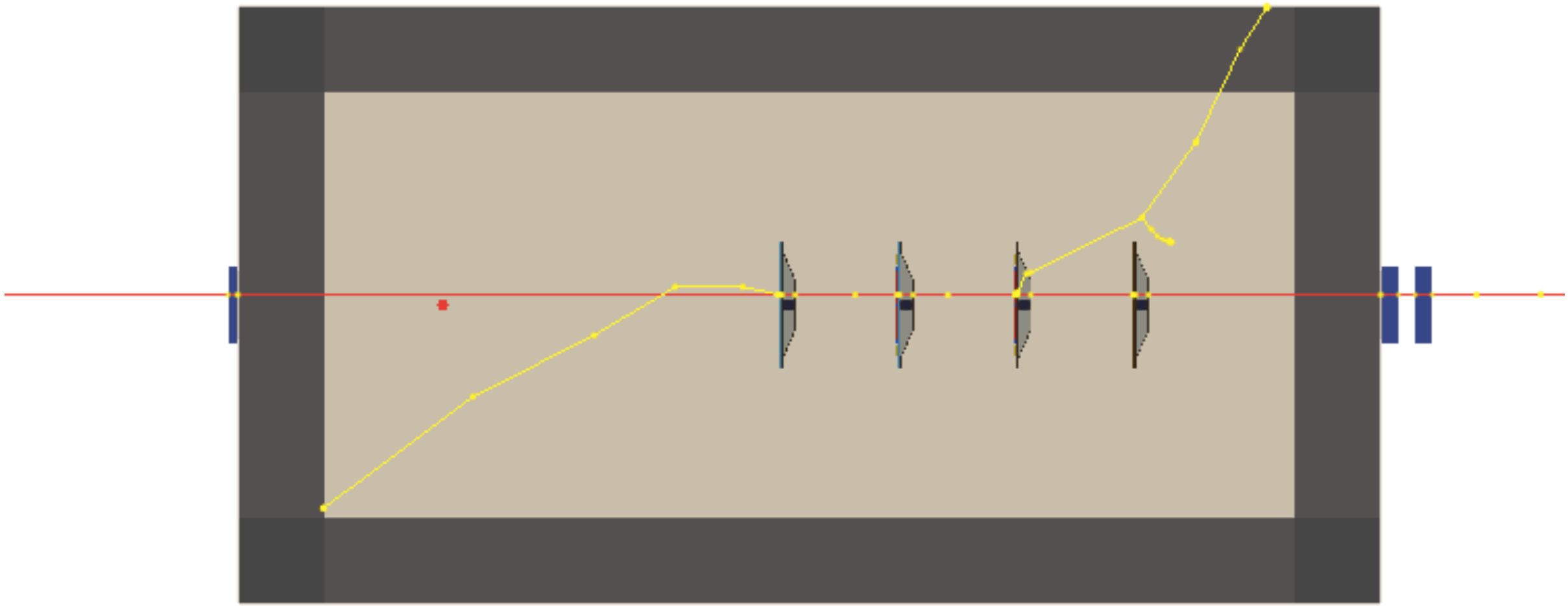





3 scintillator counter (up : 2.5mm, down 5mm *2)

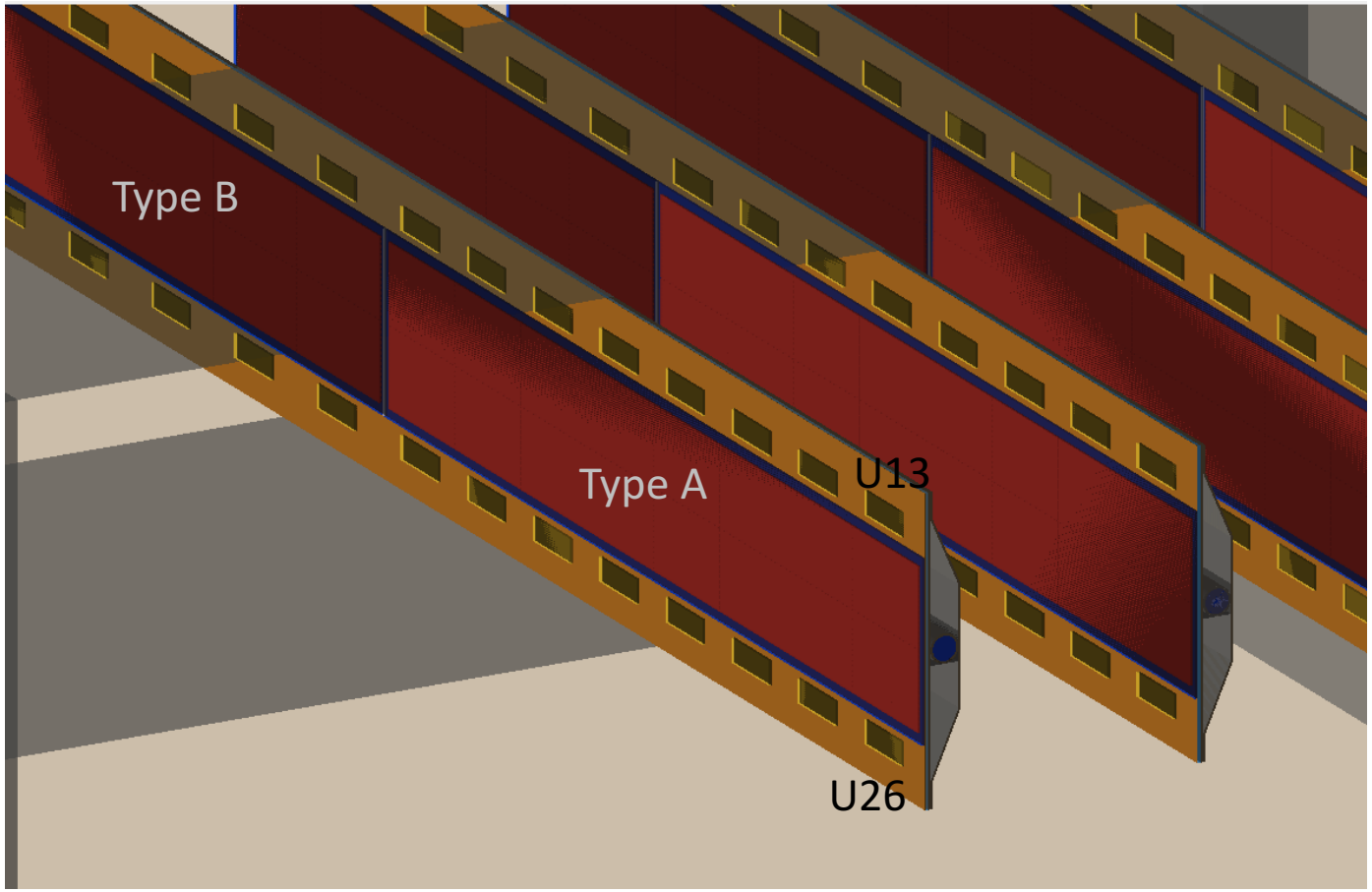


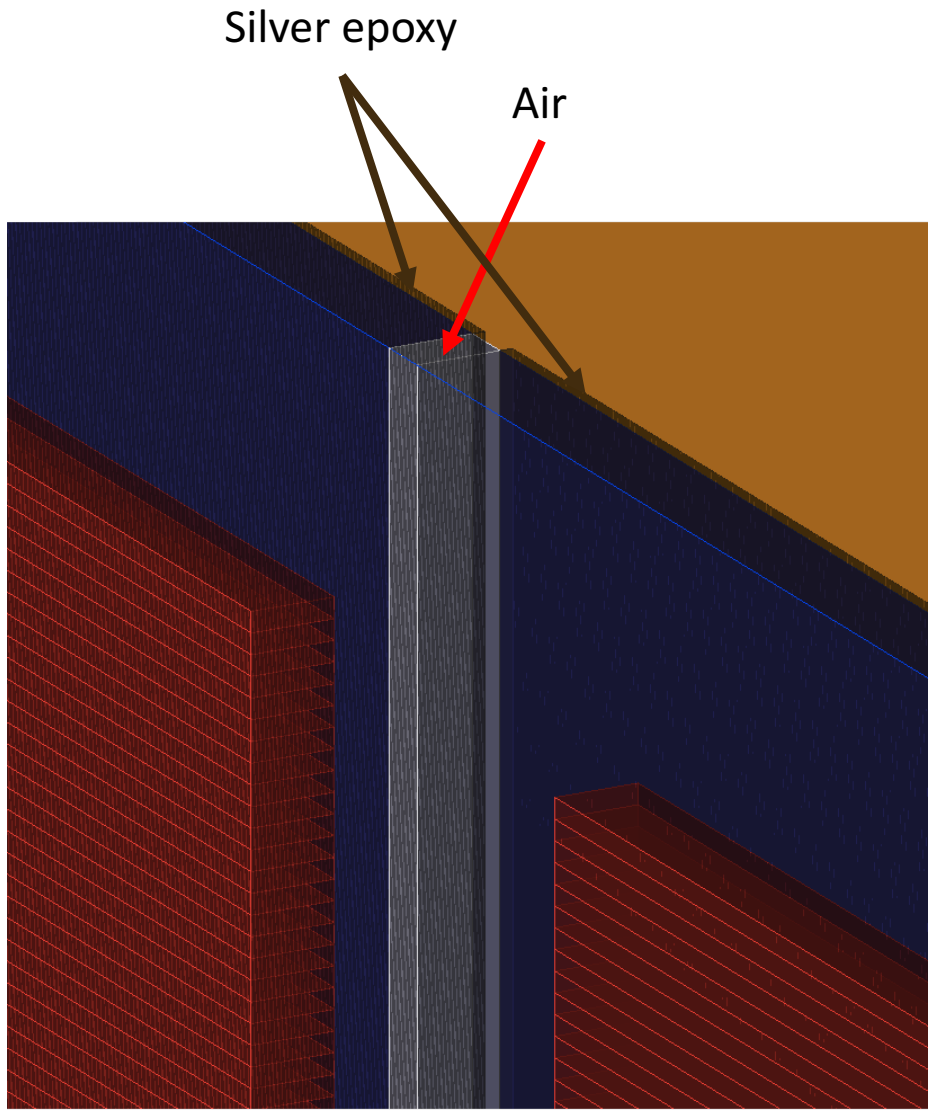





The positions of scintillators are not determined, but it is not important for us to do the trackign analysis
Scintillator “counter” we only care whether they have hits or not.

# G4 update



# G4 tracking update

MC ——> interface macro ——> filter macro ——> tracking ana macro
TestBeam ————————————> filter macro ——> tracking ana macro

Interface macro : to convert the MC data format into TestBeam data format
filter macro : to filter the double saving hits in each event.

- event = -1
- ampl = 0
- fem_id = 0
- fpga_id = 0
- Module ID
  Layer 0 : 6
  Layer 1 : 5
  Layer 2 : 8
  Layer 3 : 2

- Adc setting :
  Adc0 : 15
  Adc1 : 30
  Adc2 : 60
  Adc3 : 90
  Adc4 : 120
  Adc5 : 150
  Adc6 : 180
  Adc7 : 210

Camac_adc : edep of sci in G4 * 120.

- The branch generated by random function
- Bco : Uniform (0~127)
- Bco_full : Uniform (0 ~ 65535)
- INTT_evnet : Uniform (0~1),
  <0.9 INTT_event = 1
- Camac_tdc :
  - Tdc1 : Gaus
  - Tdc2 : Gaus
  - Tdc3 : Gaus
  - X
  - X
  - Tdc 6 : Uniform (500 ~ 1200)

- Silicon edep conversion function

mV = DAC * 4 + 210

$$mV = \frac{Edep * 10^{6}[eV] * 1.6 * 10^{-4}[fC] * G}{3.6eV} + O$$

G : 100 [mV/fC], O : 200 [mV]

# G4 tracking update

MC ——> interface macro ——> filter macro ——> tracking ana macro
TestBeam ————————————> filter macro ——> tracking ana macro

Interface macro : to convert the MC data format into TestBeam data format
filter macro : to filter the double saving hits in each event.

| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | -1 | 2 | 111 | -1 | 5 | 0 | 32768 | 156 | 216 | 0 |
| 0 | 1 | * | * | * | * | * | * | * | 142 | 240 | 0 |
| 0 | 2 | * | * | * | * | * | * | * | 138 | 369 | 0 |
| 0 | 3 | * | * | * | * | * | * | * | 0 | * | 0 |
| 0 | 4 | * | * | * | * | * | * | * | 0 | * | 0 |
| 0 | 5 | * | * | * | * | * | * | * | 626 | * | 0 |
| 1 | 0 | -1 | 2 | 117 | 6 | 2 | 35 | 16931 | 166 | 160 | 1 |
| 1 | 1 | * | * | * | * | * | * | * | 143 | 199 | 1 |
| 1 | 2 | * | * | * | * | * | * | * | 136 | 351 | 1 |
| 1 | 3 | * | * | * | * | * | * | * | 0 | * | 1 |
| 1 | 4 | * | * | * | * | * | * | * | 0 | * | 1 |
| 1 | 5 | * | * | * | * | * | * | * | 612 | * | 1 |

Cosmic data one layer

Post-conversion G4 data, 4 layers ladders

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | -1 | 5 | 62 | 6 | 3 | 20 | 10676 | 157 | 56 | 1 |
| 1 | 1 | -1 | 5 | 63 | 5 | 7 | 20 | 10676 | 140 | 103 | 1 |
| 1 | 2 | -1 | 5 | 65 | 8 | 3 | 20 | 10676 | 137 | 118 | 1 |
| 1 | 3 | -1 | 5 | 61 | 2 | 2 | 20 | 10676 | 0 | * | 1 |
| 1 | 4 | * | * | * | * | * | * | * | 0 | * | 1 |
| 1 | 5 | * | * | * | * | * | * | * | 678 | * | 1 |
| 2 | 0 | -1 | 5 | 71 | 6 | 3 | 36 | 18521 | 147 | 44 | 0 |
| 2 | 1 | -1 | 5 | 73 | 5 | 4 | 36 | 18521 | 139 | 111 | 0 |
| 2 | 2 | -1 | 5 | 78 | 8 | 3 | 36 | 18521 | 127 | 103 | 0 |
| 2 | 3 | -1 | 5 | 78 | 2 | 3 | 36 | 18521 | 0 | * | 0 |
| 2 | 4 | * | * | * | * | * | * | * | 0 | * | 0 |
| 2 | 5 | * | * | * | * | * | * | * | 1050 | * | 0 |

# G4 tracking update

MC ——> interface macro ——> filter macro ——> tracking ana macro
TestBeam ————————————> filter macro ——> tracking ana macro

Interface macro : to convert the MC data format into TestBeam data format
filter macro : to filter the double saving hits in each event.

Real cosmic data with camac system

Some hits seem to be recorded twice : 1<->3, 2<->4, 5<->7 and 6 <-> 8. I think it is ok as long as both are identical.

| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 0 | -1 | 22 | 84 | 6 | 2 | 111 | 62063 | 138 | 204 | 1 |
| 17 | 1 | -1 | 22 | 83 | 6 | 1 | 111 | 62063 | 140 | 206 | 1 |
| 17 | 2 | -1 | 22 | 85 | 6 | 1 | 111 | 62063 | 167 | 245 | 1 |
| 17 | 3 | -1 | 22 | 83 | 6 | 1 | 112 | 62064 | 0 | | 1 |
| 17 | 4 | -1 | 22 | 85 | 6 | 1 | 112 | 62064 | 0 | | 1 |
| 17 | 5 | -1 | 21 | 103 | 5 | 7 | 113 | 62065 | 676 | | 1 |
| 17 | 6 | -1 | 16 | 0 | 5 | 0 | 113 | 62065 | | | 1 |
| 17 | 7 | -1 | 21 | 103 | 5 | 7 | 114 | 62066 | | | 1 |
| 17 | 8 | -1 | 16 | 0 | 5 | 0 | 114 | 62066 | | | 1 |

One event

But if you check another event shown below, you can see there is one hit recorded twice but with different adc….

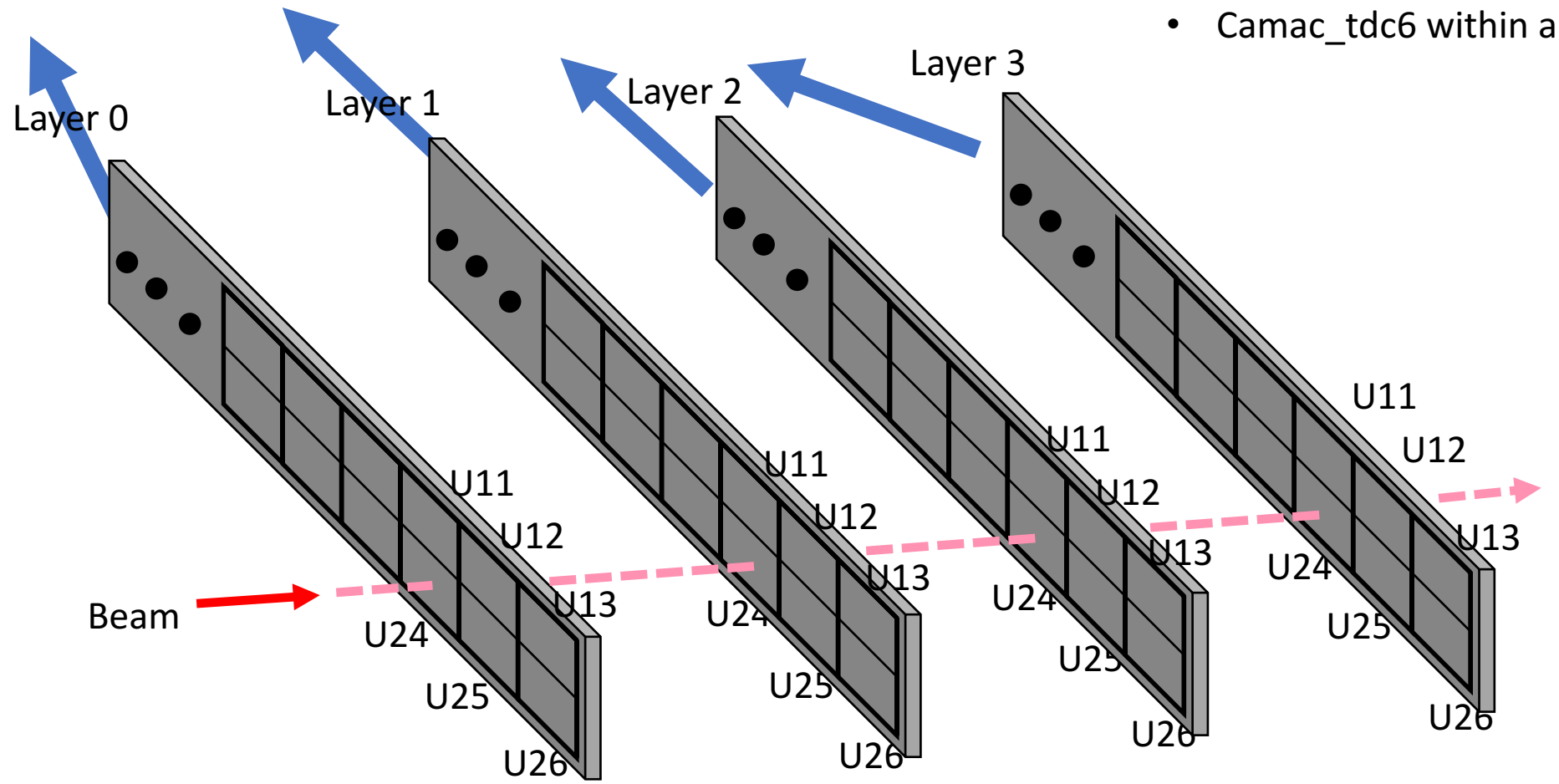
| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 0 | -1 | 21 | 127 | 5 | 7 | 90 | 53850 | 156 | 161 | 1 |
| 11 | 1 | -1 | 21 | 126 | 5 | 1 | 90 | 53850 | 140 | 212 | 1 |
| 11 | 2 | -1 | 21 | 126 | 5 | 7 | 90 | 53850 | 132 | 379 | 1 |
| 11 | 3 | -1 | 5 | 107 | 6 | 2 | 90 | 53850 | 0 | | 1 |
| 11 | 4 | -1 | 21 | 8 | 5 | 7 | 90 | 53850 | 0 | | 1 |
| Type <CR> to continue or q to quit ==> | | | | | | | | | | | |
| 11 | 5 | -1 | 21 | 120 | 5 | 3 | 90 | 53850 | 600 | | 1 |
| 11 | 6 | -1 | 21 | 5 | 5 | 2 | 90 | 53850 | | | 1 |
| 11 | 7 | -1 | 16 | 0 | 5 | 0 | 90 | 53850 | | | 1 |
| 11 | 8 | -1 | 21 | 66 | 5 | 6 | 91 | 53851 | | | 1 |
| 11 | 9 | -1 | 16 | 0 | 5 | 0 | 91 | 53851 | | | 1 |

One event

It will effect on tracking result as the energy-weighted method is applied.

Tracking algorithm

- Event criteria :
  - Scintillator 3 hits
  - Camac_adc < certain enegy
  - Camac_tdc6 within a certain range

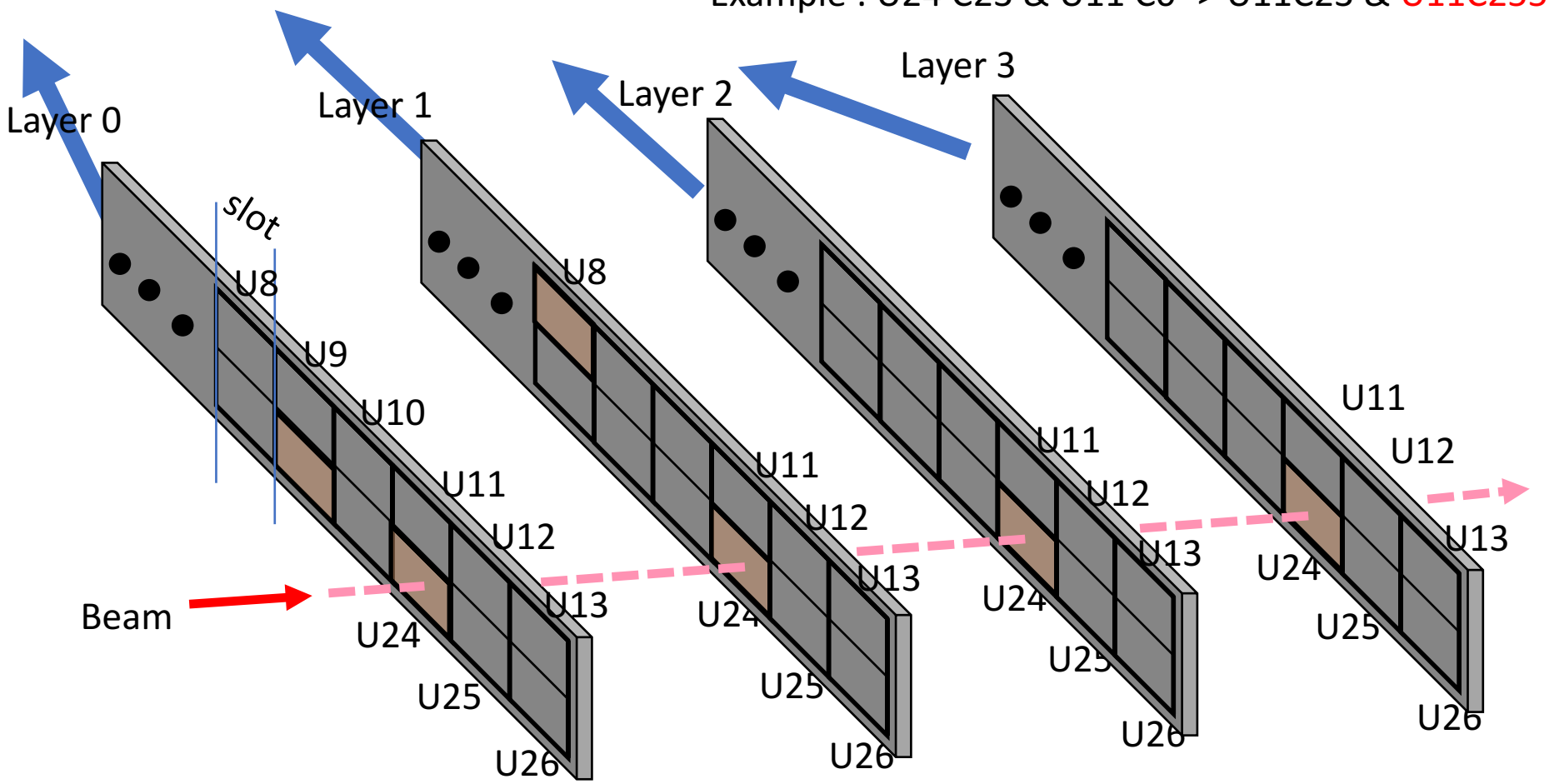



1. Working on layer efficiency study
2. Sensor alignment trial

Tracking algorithm

INTT Testbeam2021 : no magnetic field → beam trajectory : straight line
→ we vote to pick up the real event

- Up section (U1) and down section (U14) are consider as same “slot”
  - Example : U24 C23 & U11 C0 -> U11C23 & U11C255




: this chip that has some hits

Vote : as long as the slot has >0 event → slot gets one vote

Election result of this event :

U8 = 1, U9 =1, U11=4

Tracking algorithm

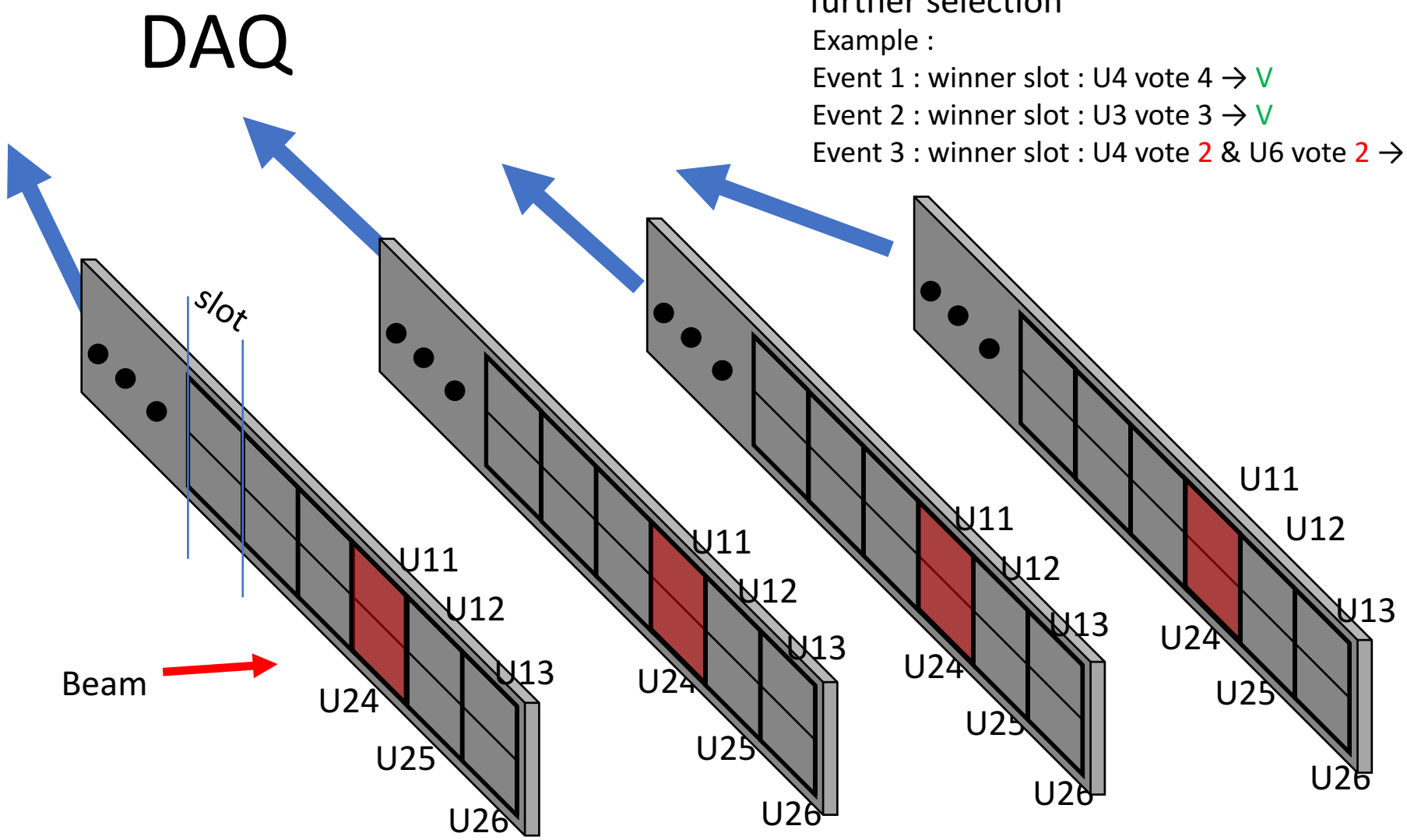
I require at least 3 votes the winner slot should have for further selection

Example :

Event 1 : winner slot : U4 vote 4 → V

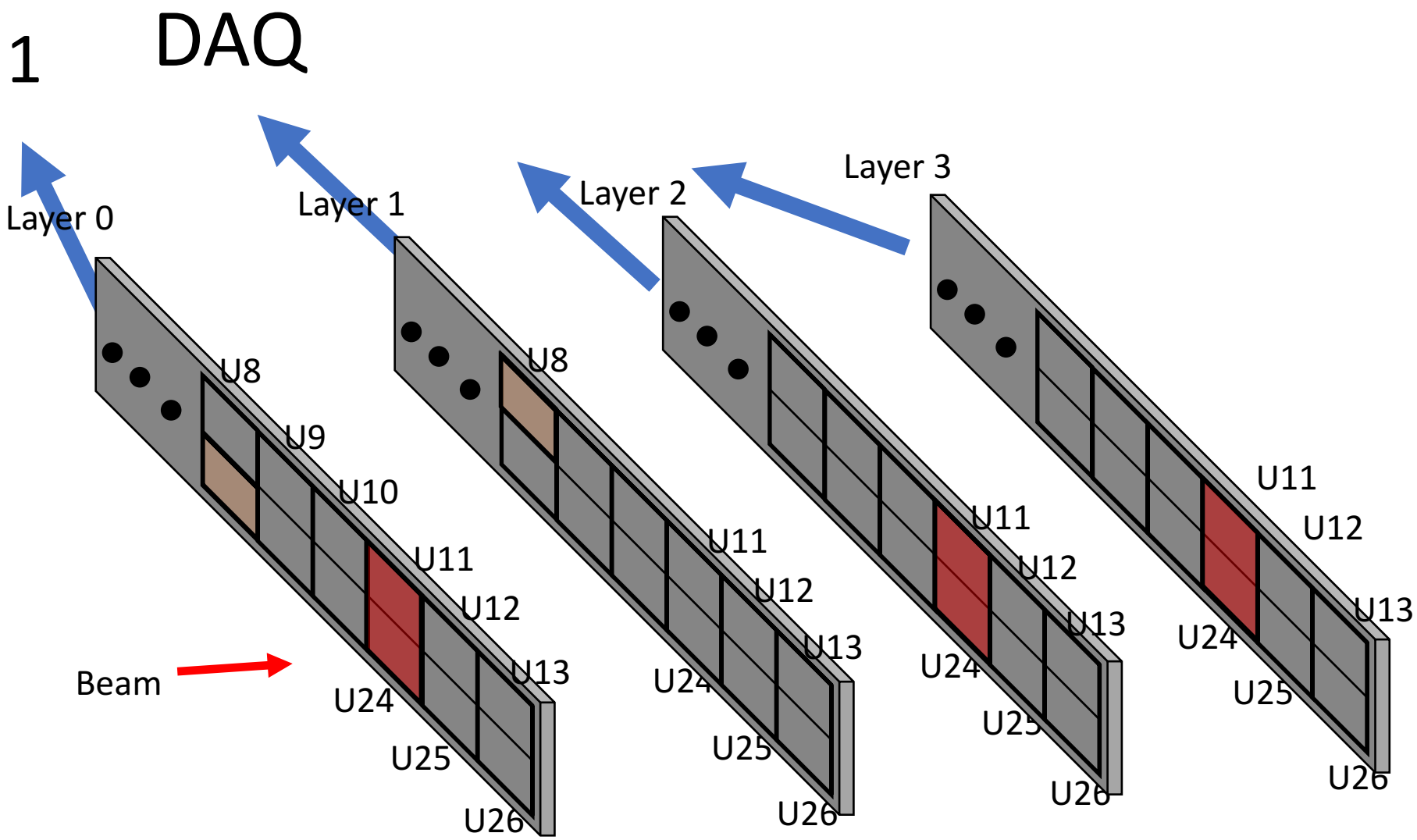
Event 2 : winner slot : U3 vote 3 → V

Event 3 : winner slot : U4 vote 2 & U6 vote 2 → X, the event is skipped




: The slot that wins the election U11

# Example 1



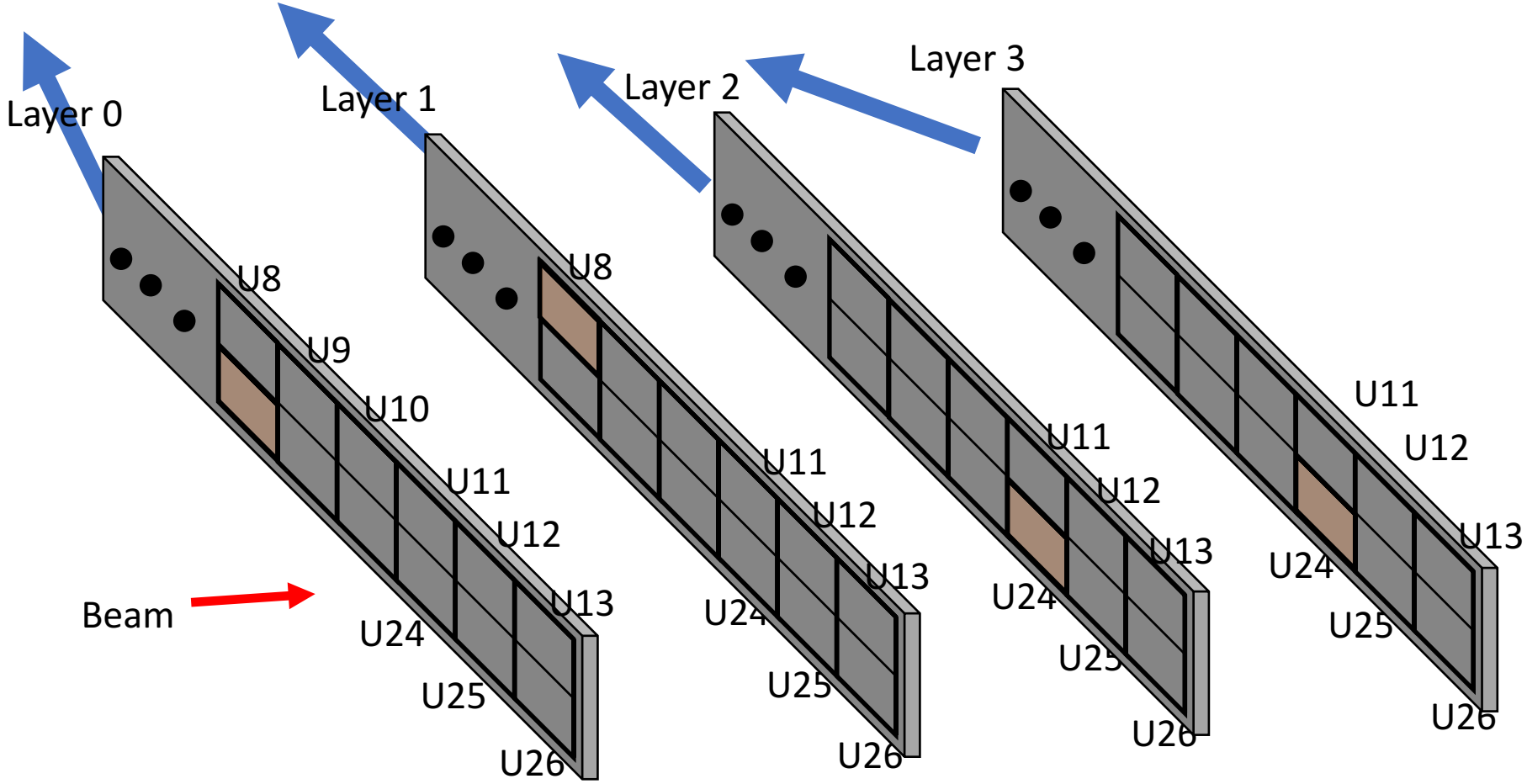

: this chip that has some hits

: The slot that wins the election U11

U8 vote : 2, U11 vote 3 → ok for further selection

# Example 2

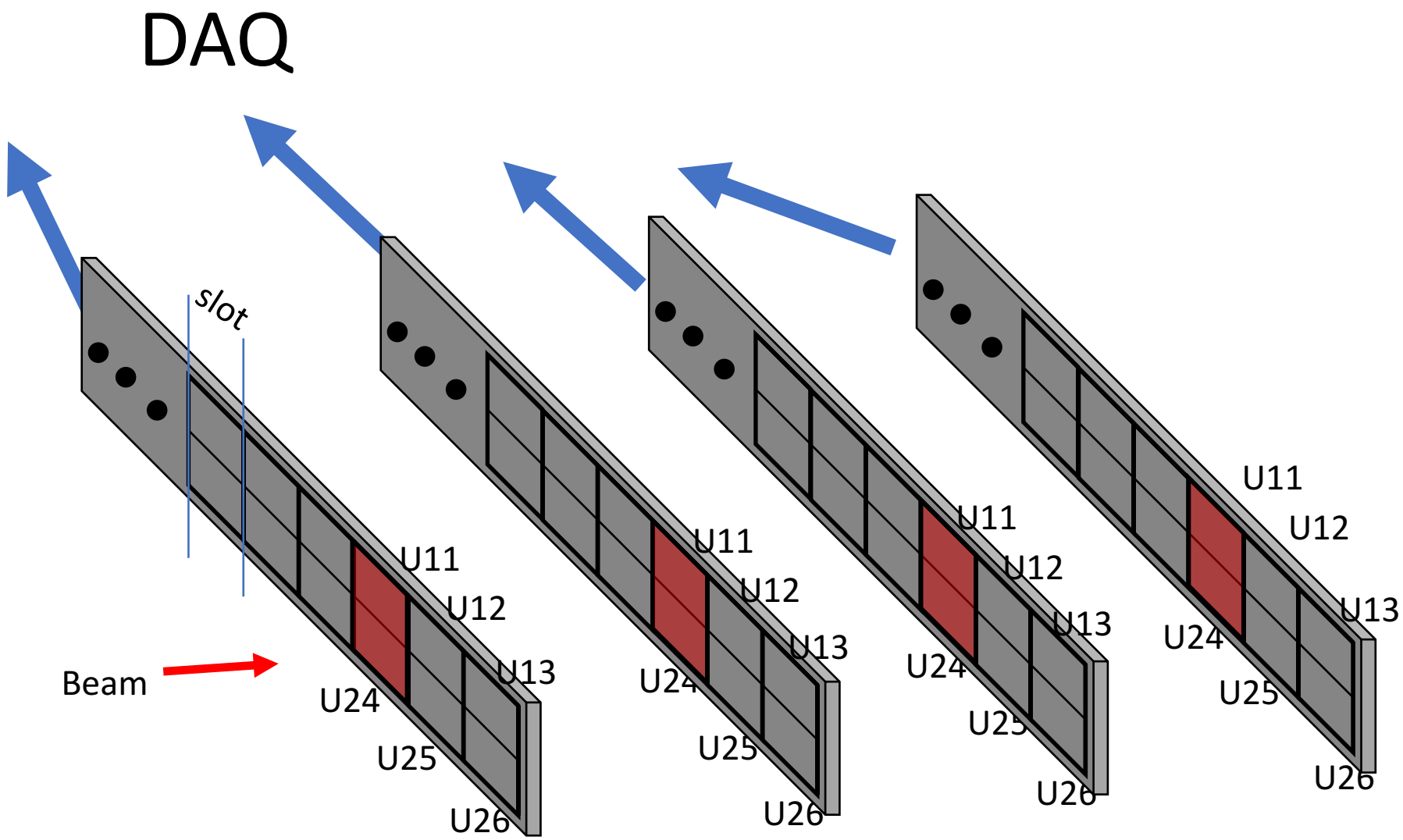
DAQ




: this chip that has some hits

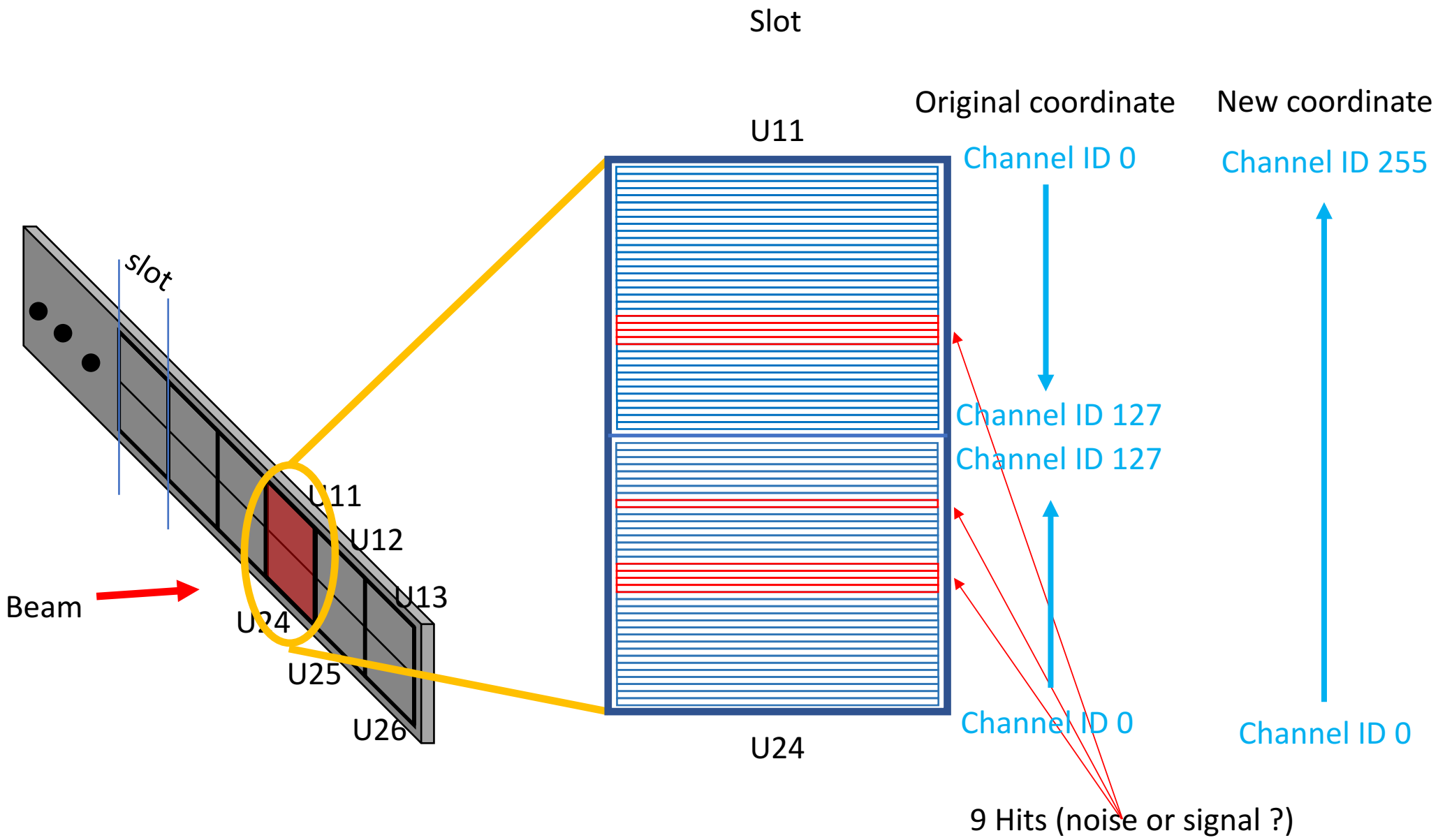
U8 vote : 2, U11 vote 2 -> this event will be skipped

Tracking algorithm

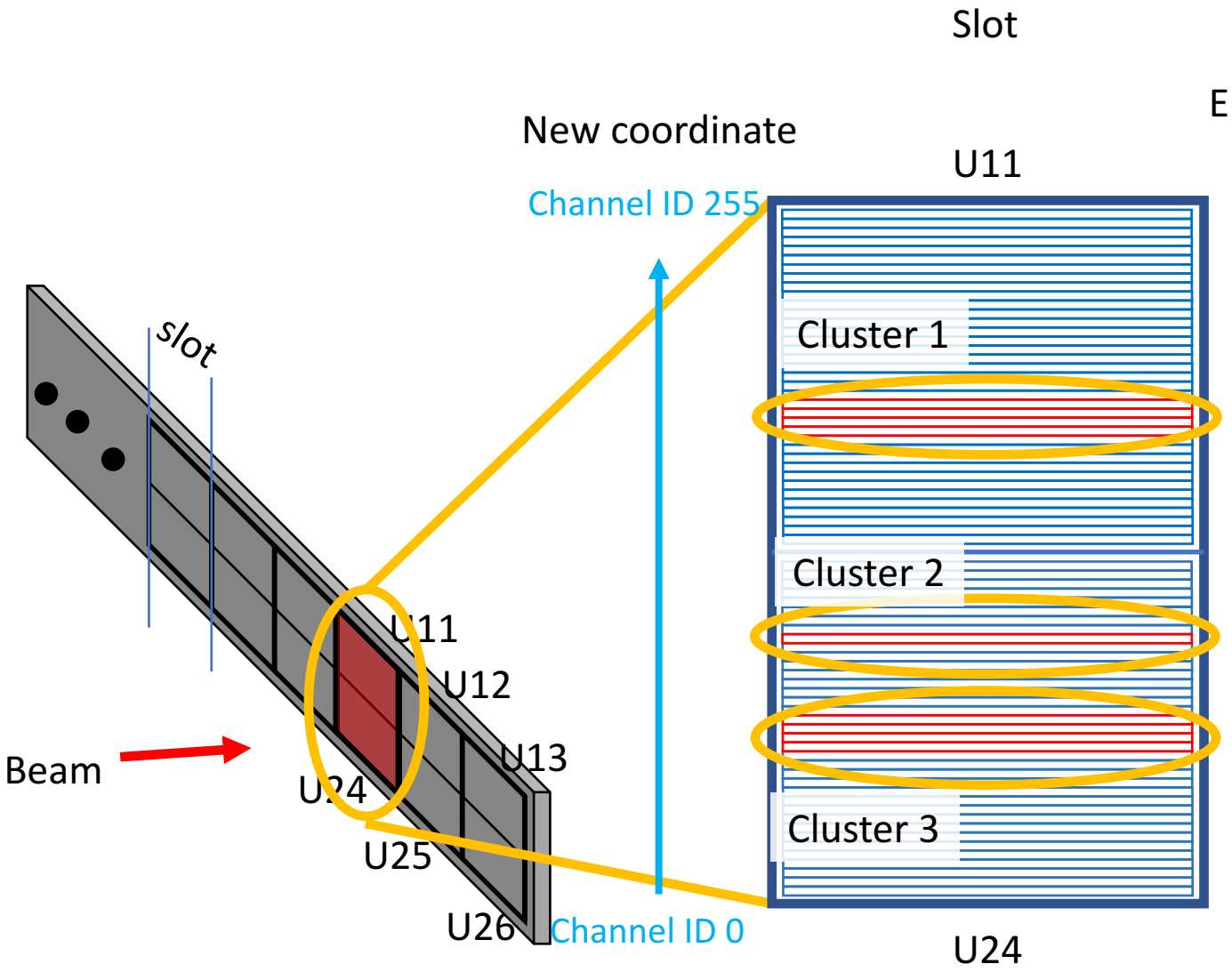



: The slot that wins the election U11

# Tracking algorithm



# Tracking algorithm




Energy-weighted method is applied

$$P_j = \frac{\sum_n C_n E_n}{\sum_n E_n}$$

$C_n$ : position (mm) in y-axis of channel n in cluster

$E_n$ : energy deposit of channel n in cluster

$P_j$ : final position in y-axis of cluster j

Cluster : the adjacent channels

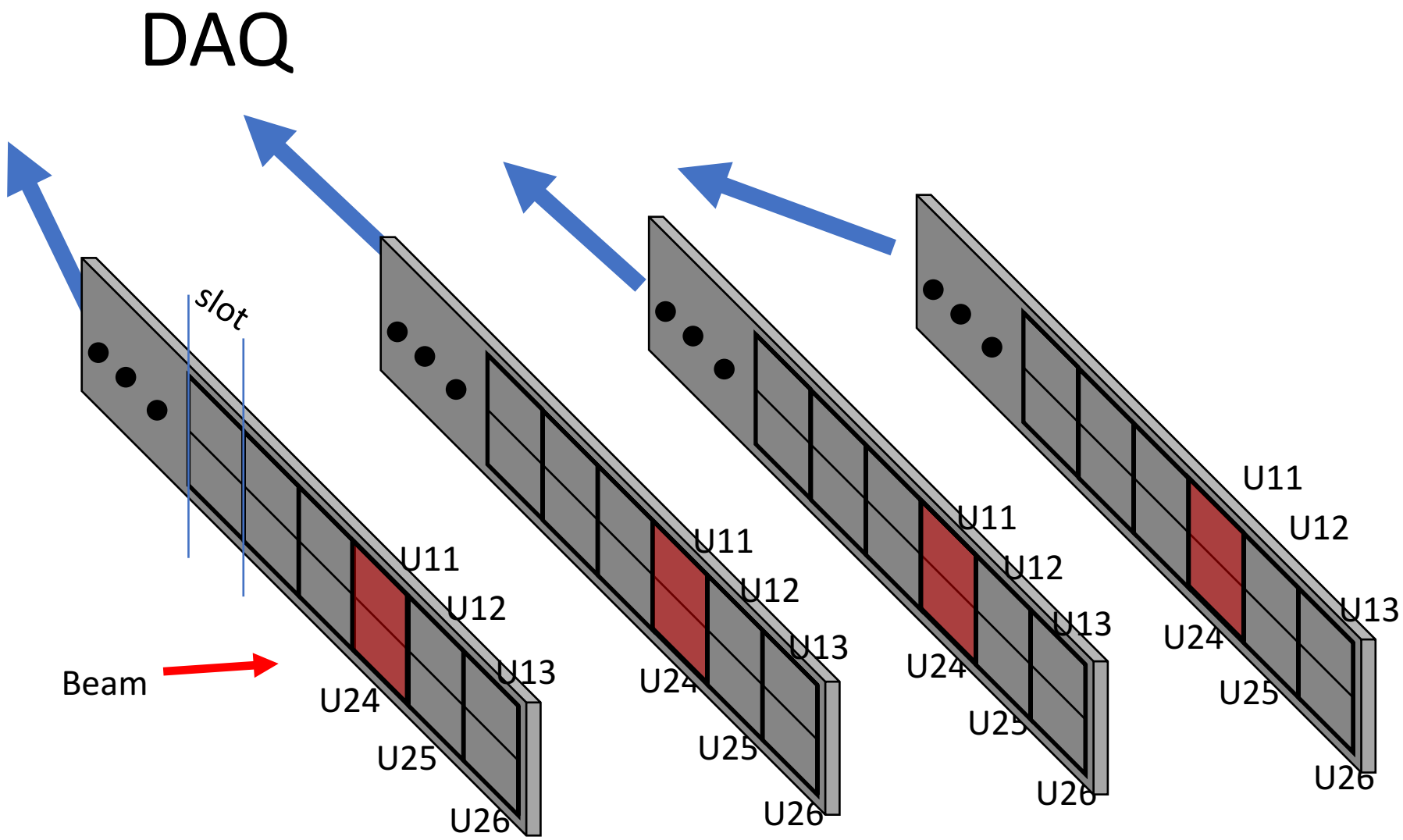
Cluster 1 Cluster 2

Chan_id : 3 4 5 6 8 9 10

reduce

9 fired-channels -> 3 positions

Tracking algorithm



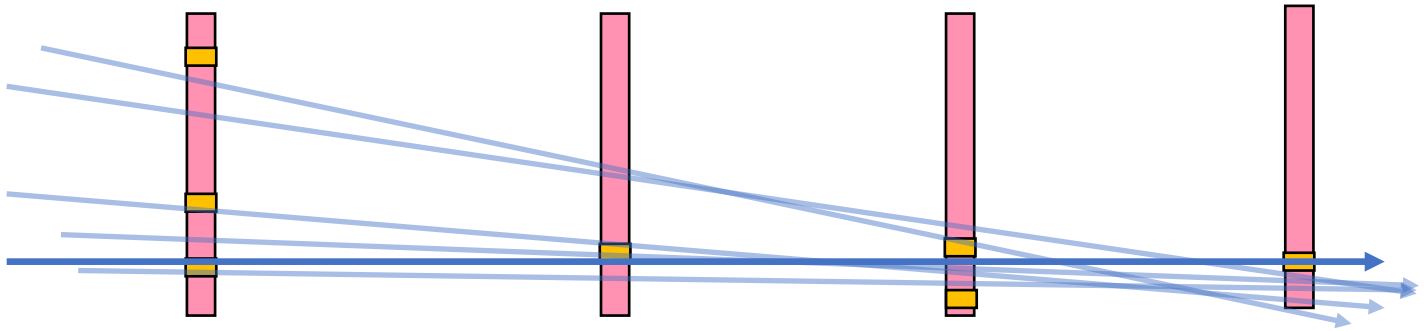

: The slot that wins the election U11

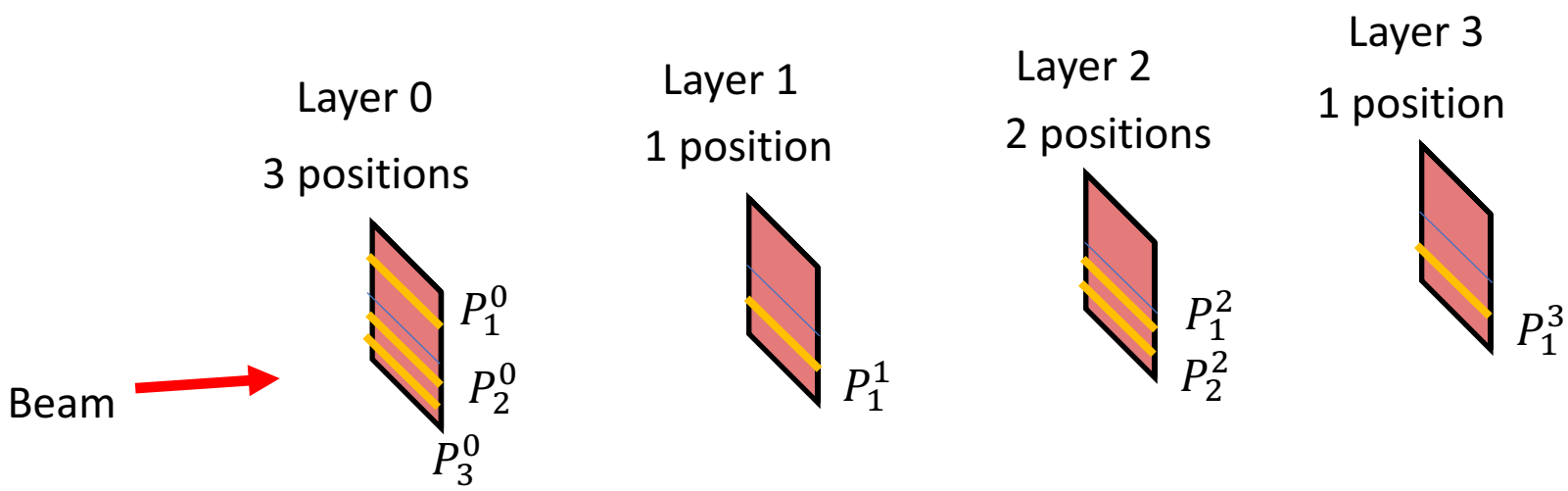
# Tracking algorithm

3 x 1 x 2 x 1 = 6 combinations !

We fit 6 times and pick up one with minimum $\chi$2/NDF

| L0 | l1 | l2 | l3 | |
|---|---|---|---|---|
| P1 | p1 | p1 | p1 | First fit |
| P2 | p1 | p1 | p1 | Second fit |
| P3 | p1 | p1 | p1 | |
| P1 | p1 | p2 | p1 | |
| P2 | p1 | p2 | p1 | |
| P3 | p1 | p2 | p1 | |



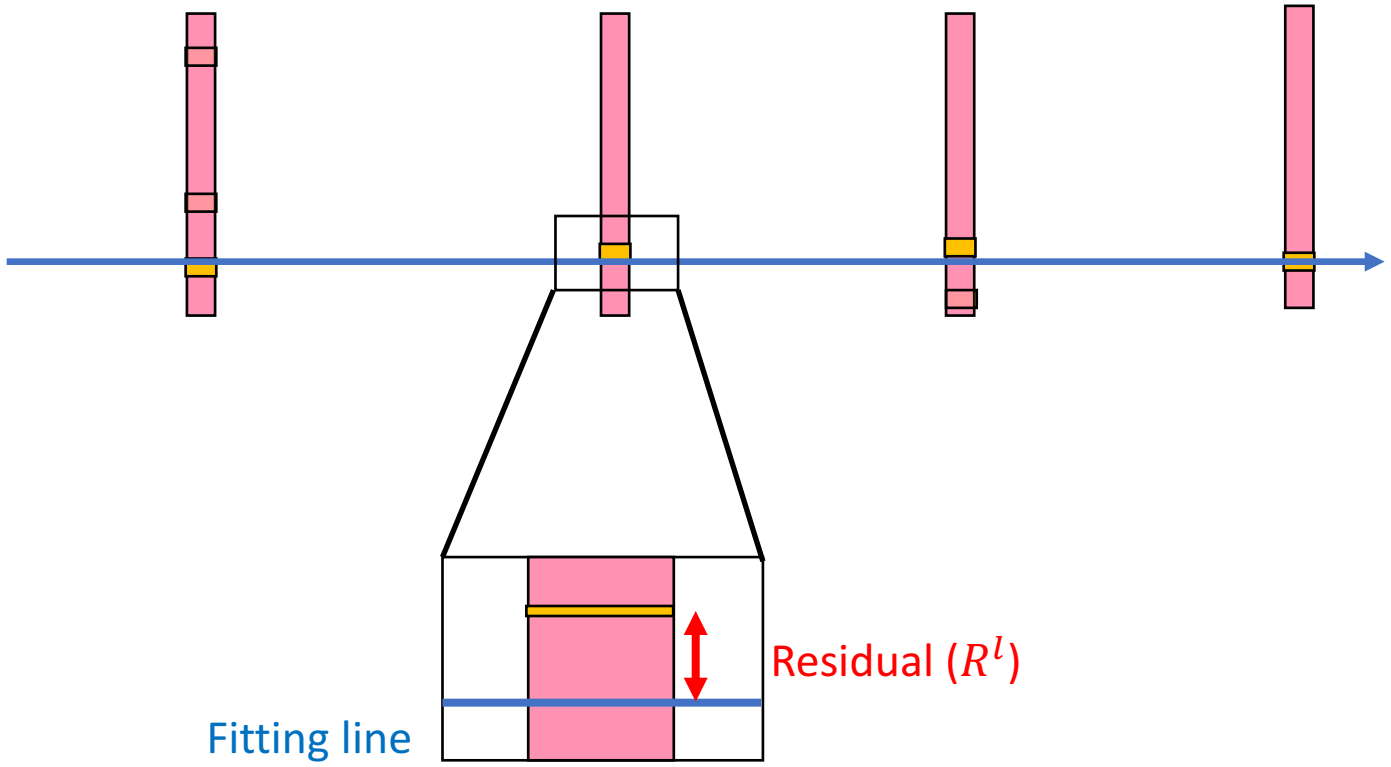



3 x 1 x 2 x 1 = 6 combinations !

$P_j^l$ : the position in Y axis of layer $\ell$ and cluster j

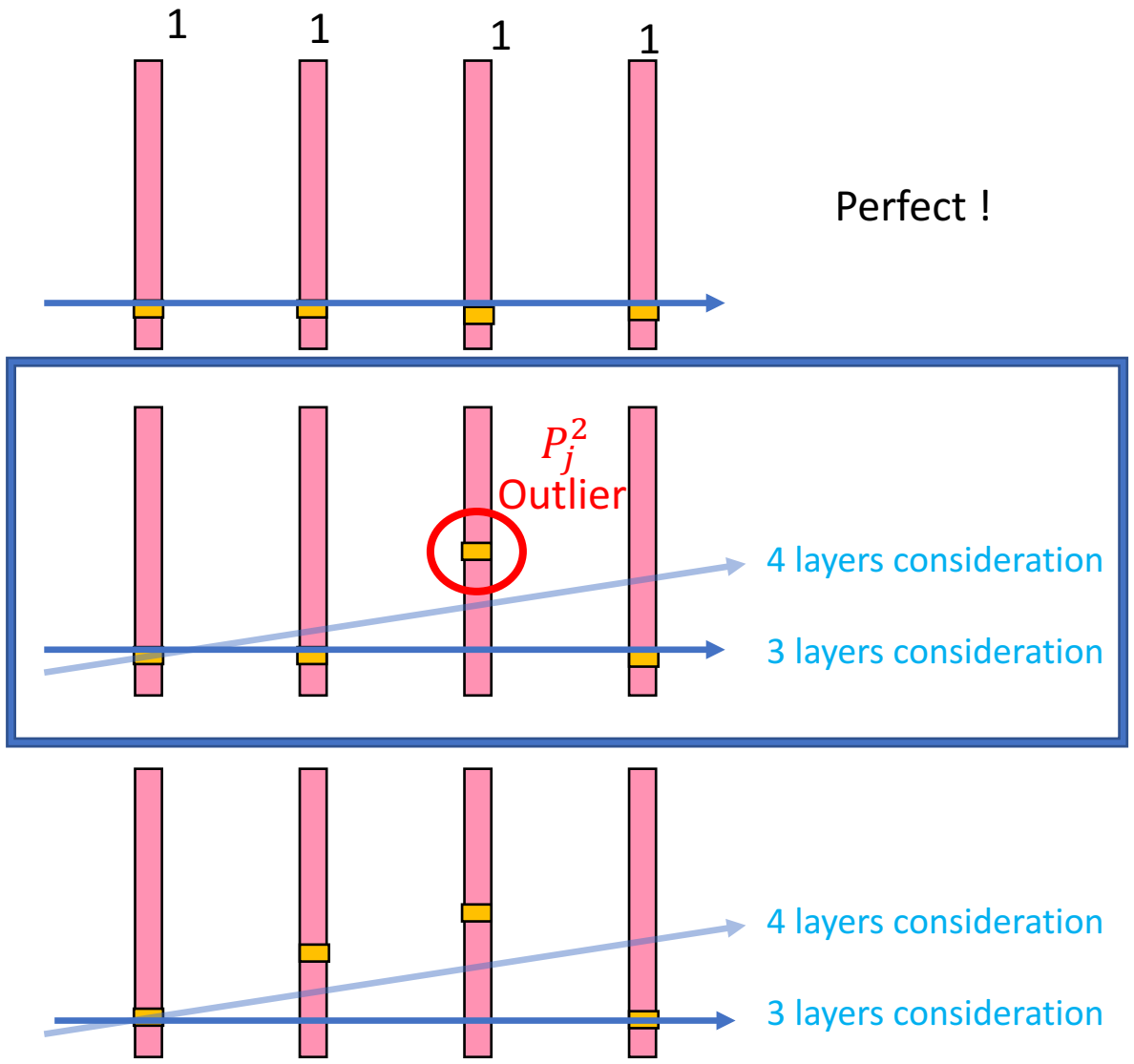
# Tracking algorithm

We calculate the residual in y-axis between the fitting line and $P_j^l$




"a certain cut" : 5 * INTT strip width so far :5*0.078 mm
If the $R^l$ > "a certain cut" { layer decode = 0}
Else { layer decode = 1}

# 4 hit layers case



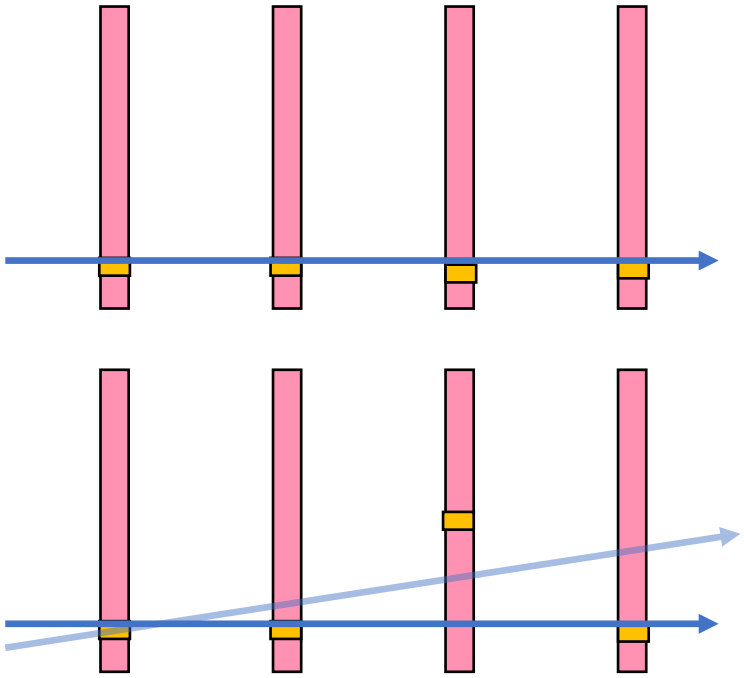

If the residual of one of layer > ”a certain cut” (5*0.078 mm)

Pick up the outlier by finding Maximum of
$|(P_j^a + P_j^b + P_j^c)/3 - P_j^d|$, a≠ b ≠ c ≠d
In the example : $|(P_j^0 + P_j^1 + P_j^3)/3 - P_j^2|$

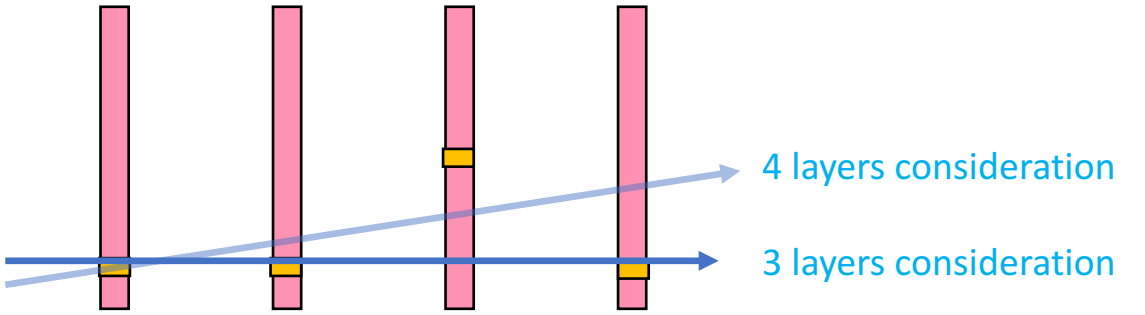
Fit again with remaining points, and check the residual
If the residual of remaining points < ”a certain cut” → good

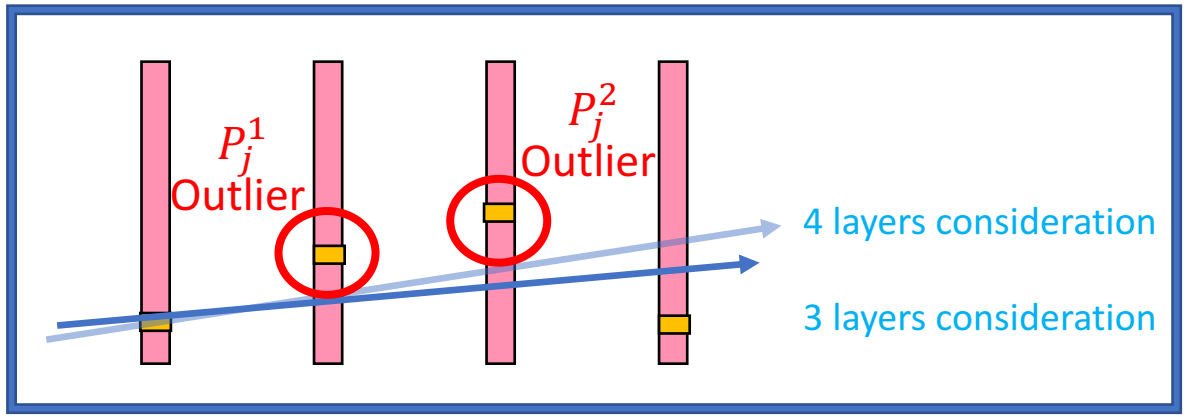
In the example : final result : 1 1 0 1

# 4 hit layers case



Perfect !




If the residual of one of layer > ”a certain cut” (5*0.078 mm)

Pick up the outlier by finding Maximum of
$|(P_j^a + P_j^b + P_j^c)/3 - P_j^d|$, a≠ b ≠ c ≠d
In the example : $|(P_j^0 + P_j^1 + P_j^3)/3 - P_j^2|$

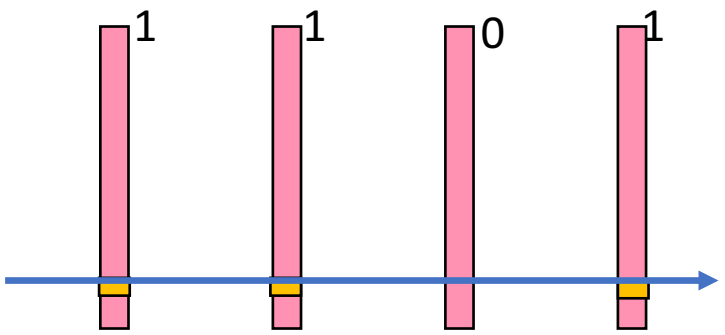
Fit again with remaining points, and check the residual
If the residual of remaining points > ”a certain cut”

Pick up the outlier by finding Minimum
among the following combinations :
$|P_j^a - P_j^b|$ or $|P_j^a - P_j^c|$ or $|P_j^b - P_j^c|$, a≠ b ≠ c

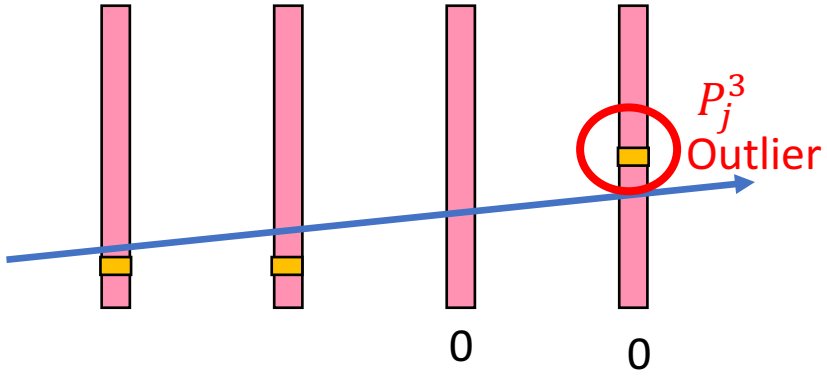
In the example : the minimum is $|P_j^0 - P_j^3|$

Final result of this example : 1 0 0 1

# 3 hit layers case




Perfect !




Pick up the outlier by finding Minimum among the following combinations :

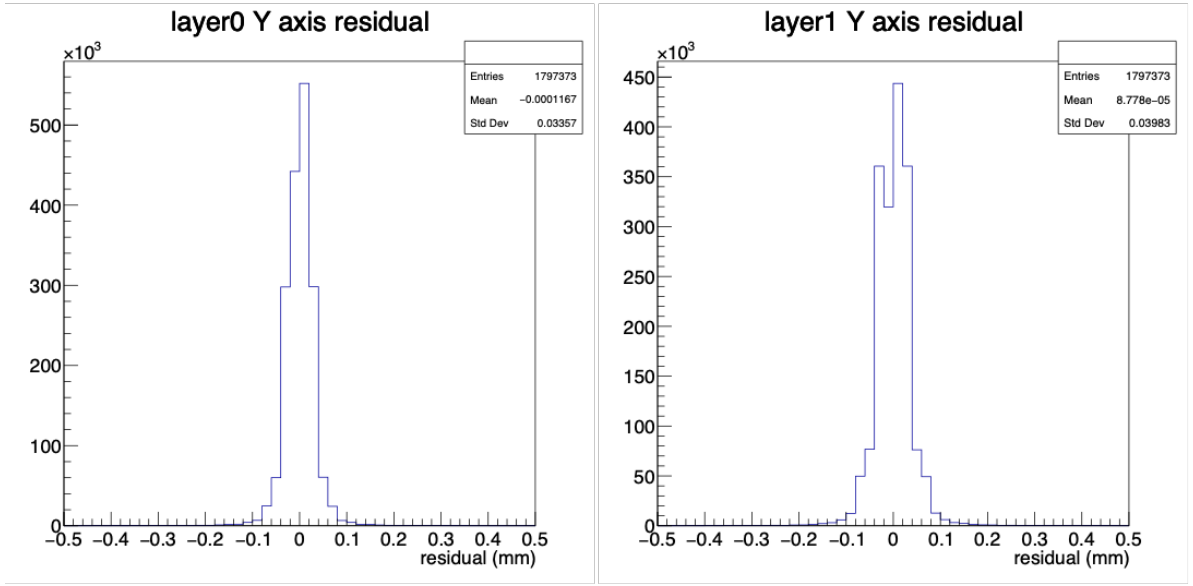
$|P_j^a - P_j^b|$ or $|P_j^a - P_j^c|$ or $|P_j^b - P_j^c|$, a≠ b ≠ c

In the example : the minimum is $|P_j^0 - P_j^1|$

Final result of this event : 1 1 0 0

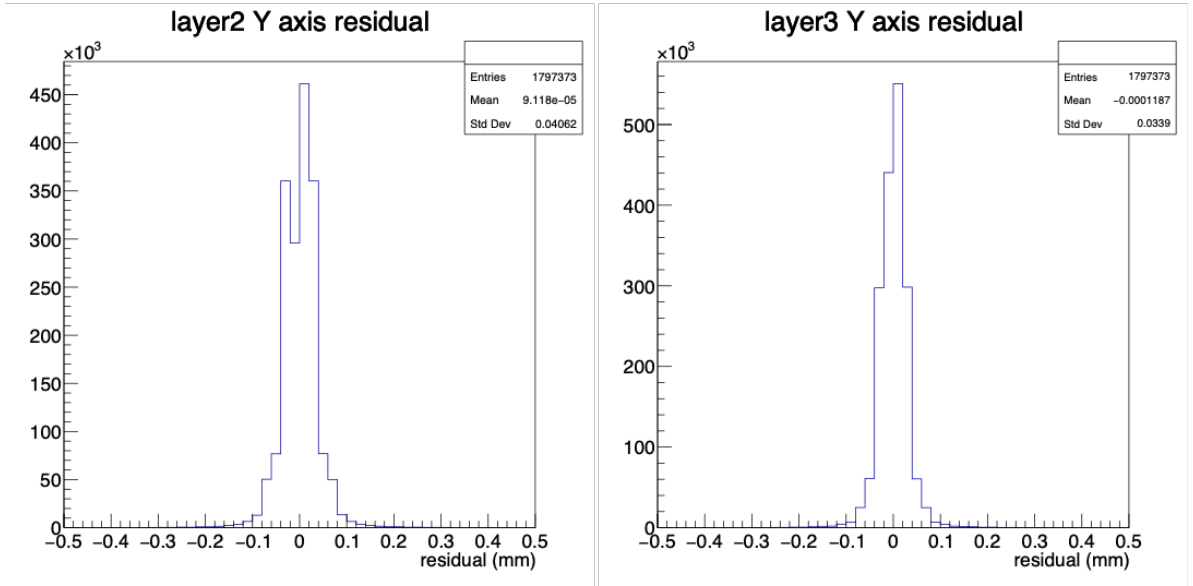
# Tracking result

All ladders are aligned, no offset



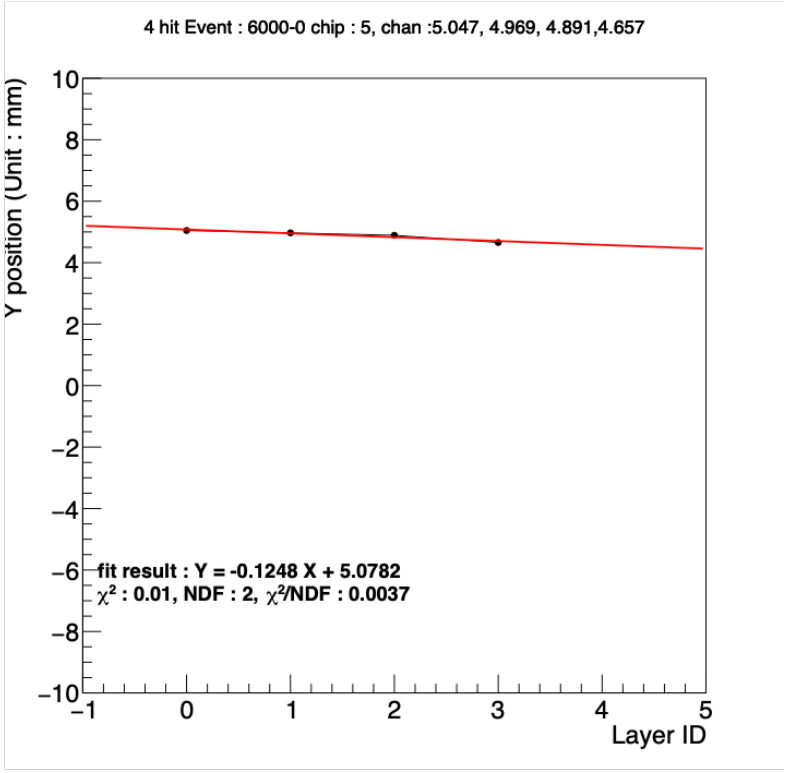






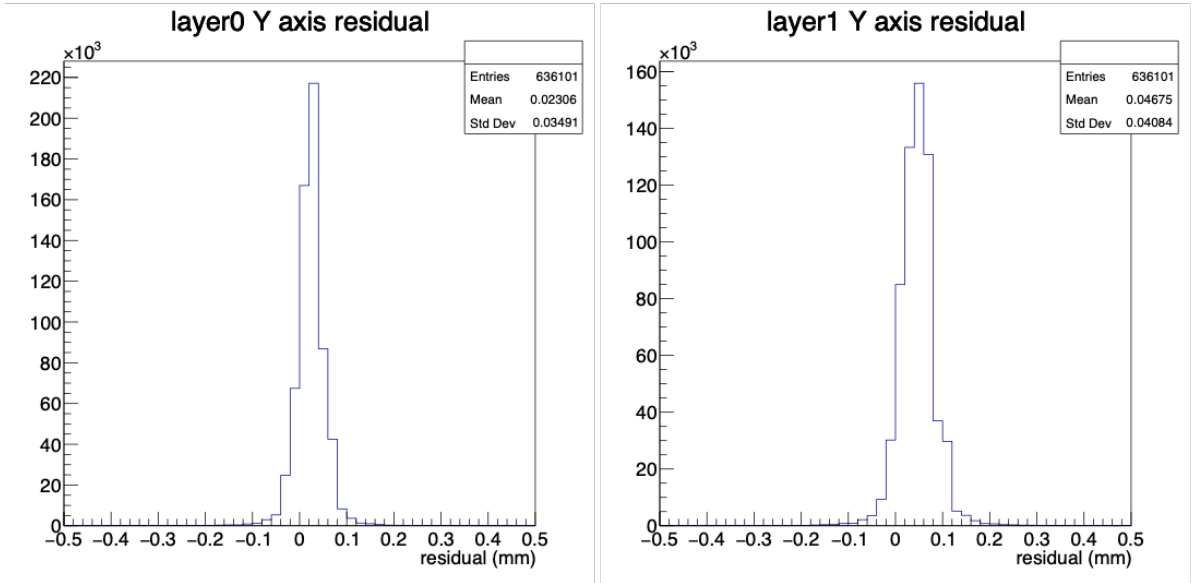






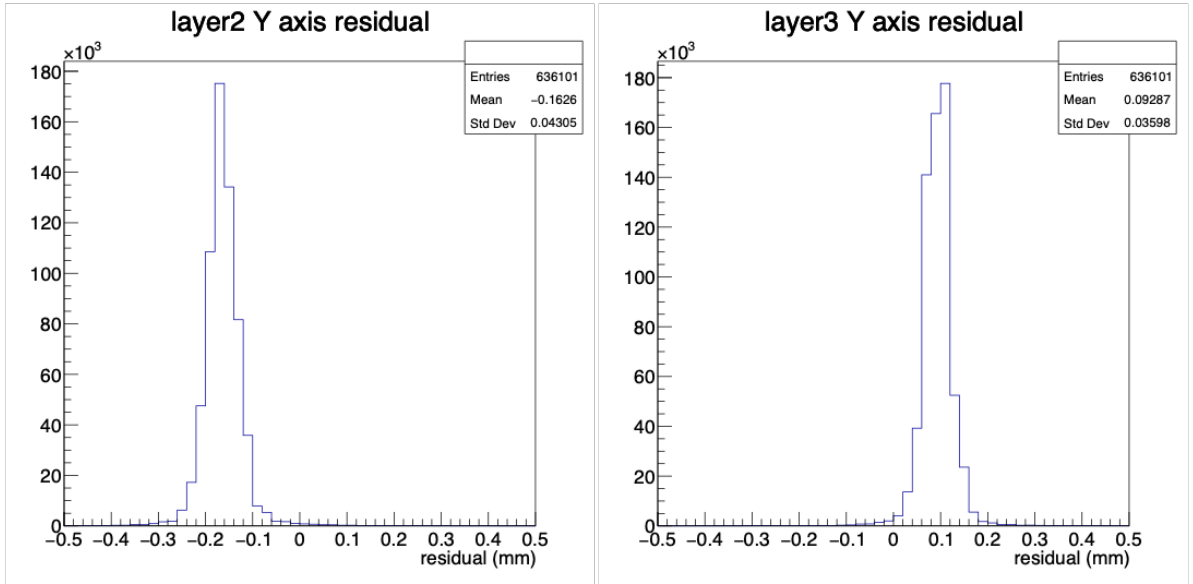
# Tracking result

Ladder 2 has a + 234 μm offset in Y axis



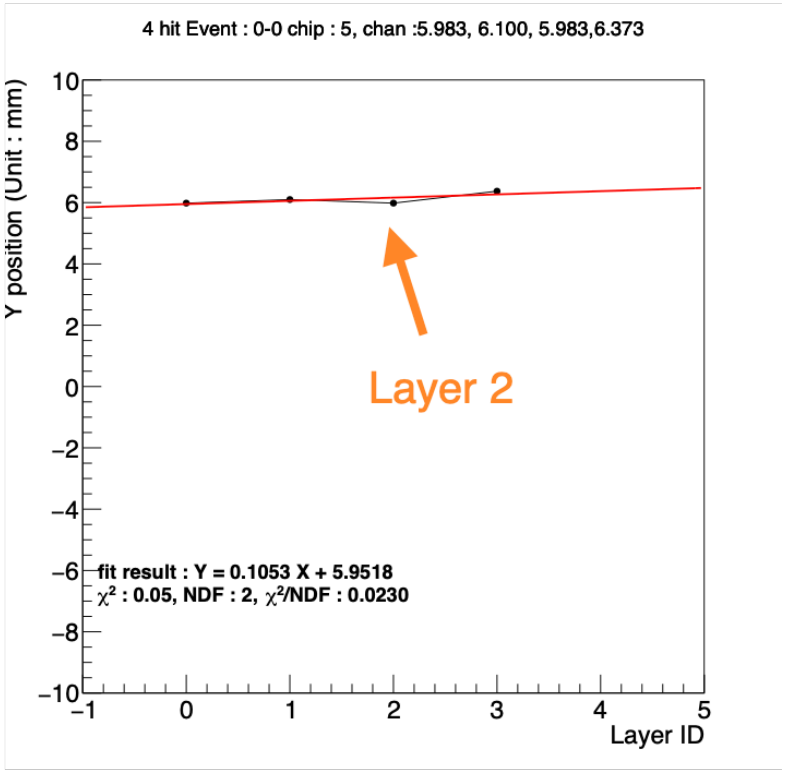




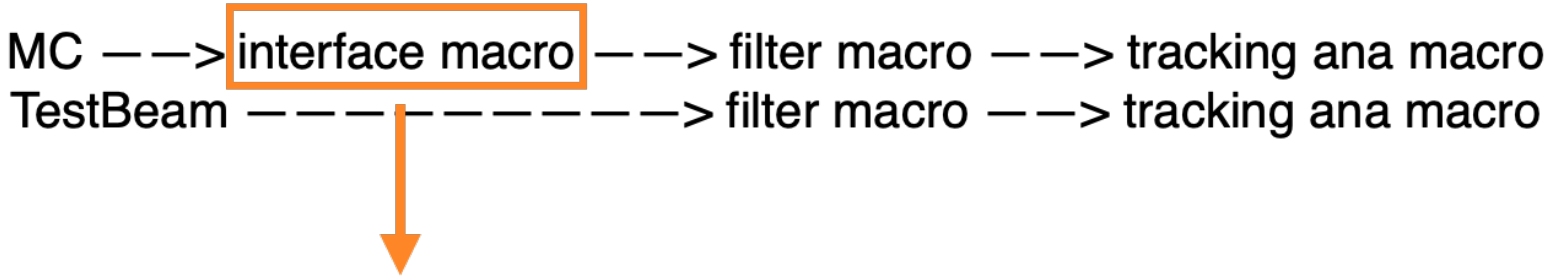








# Tracking result




```
Fskip_event = skip_event-> Uniform(0,1);
if (Zpos == 1 && Fskip_event > 0.7) {continue;}
```

Forcibly set the efficiency of layer 1 to be 70%

Without the efficiency setting

```
==========efficiency results==========
|| l0 : 99.97025 %
|| l1 : 99.99097 %
|| l2 : 99.98573 %
|| l3 : 99.84207 %
==========efficiency results==========
```

With the efficiency setting

```
==========efficiency results==========
|| l0 : 99.96784 %
|| l1 : 71.12692 %
|| l2 : 99.98329 %
|| l3 : 99.87855 %
==========efficiency results==========
```

My code seems to be working

# Back up

- Back up

- Slope constrain ?

11/17 arrive JP

My plan would be :
I generate one root file based on G4 MC
I send the MCdata to you.  “.root file”
And you use your code to get the efficiency result
And cross check with mine.

“We use the same data“ and then to see whether we can get same efficiency result.

Tacking!!  Develop an algorithm to study the efficiency.

20cm CC /40 cm “most”
120 BEC + 20cm CC  (optional)
120 BEC + 20cm MCC

https://drive.google.com/drive/folders/12CNNvB7X746o-rO-5-7_1N0p3STpC1Vu

Definition of efficiency : # of case of (1111)/ # of case of (0111+1111)
Std dev of the cluster

Beam 12/7 ~ 12/10

| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 0 | -1 | 22 | 84 | 6 | 2 | 111 | 62063 | 138 | 204 | 1 |
| 17 | 1 | -1 | 22 | 83 | 6 | 1 | 111 | 62063 | 140 | 206 | 1 |
| 17 | 2 | -1 | 22 | 85 | 6 | 1 | 111 | 62063 | 167 | 245 | 1 |
| 17 | 3 | -1 | 22 | 83 | 6 | 1 | 112 | 62064 | 0 | | 1 |
| 17 | 4 | -1 | 22 | 85 | 6 | 1 | 112 | 62064 | 0 | | 1 |
| 17 | 5 | -1 | 21 | 103 | 5 | 7 | 113 | 62065 | 676 | | 1 |
| 17 | 6 | -1 | 16 | 0 | 5 | 0 | 113 | 62065 | | | 1 |
| 17 | 7 | -1 | 21 | 103 | 5 | 7 | 114 | 62066 | | | 1 |
| 17 | 8 | -1 | 16 | 0 | 5 | 0 | 114 | 62066 | | | 1 |
| **17** | **9** | **-1** | **22** | **83** | **5** | **3** | **115** | **62067** | | | **1** |
| **17** | **10** | **-1** | **22** | **84** | **8** | **1** | **115** | **62067** | | | **1** |
| **17** | **11** | **-1** | **22** | **83** | **2** | **0** | **116** | **62068** | | | **1** |

Some hits seem to be recorded twice : 1<->3, 2<->4, 5<->7 and 6 <-> 8. I think it is ok as long as both are identical.

| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 0 | -1 | 22 | 84 | 6 | 2 | 111 | 62063 | 138 | 204 | 1 |
| 17 | 1 | -1 | 22 | 83 | 6 | 1 | 111 | 62063 | 140 | 206 | 1 |
| 17 | 2 | -1 | 22 | 85 | 6 | 1 | 111 | 62063 | 167 | 245 | 1 |
| 17 | 3 | -1 | 22 | 83 | 6 | 1 | 112 | 62064 | 0 | | 1 |
| 17 | 4 | -1 | 22 | 85 | 6 | 1 | 112 | 62064 | 0 | | 1 |
| 17 | 5 | -1 | 21 | 103 | 5 | 7 | 113 | 62065 | 676 | | 1 |
| 17 | 6 | -1 | 16 | 0 | 5 | 0 | 113 | 62065 | | | 1 |
| 17 | 7 | -1 | 21 | 103 | 5 | 7 | 114 | 62066 | | | 1 |
| 17 | 8 | -1 | 16 | 0 | 5 | 0 | 114 | 62066 | | | 1 |

But if you check another event shown below, you can see there is one hit recorded twice but with different adc….

| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 0 | -1 | 21 | 127 | 5 | 7 | 90 | 53850 | 156 | 161 | 1 |
| 11 | 1 | -1 | 21 | 126 | 5 | 1 | 90 | 53850 | 140 | 212 | 1 |
| 11 | 2 | -1 | 21 | 126 | 5 | 7 | 90 | 53850 | 132 | 379 | 1 |
| 11 | 3 | -1 | 5 | 107 | 6 | 2 | 90 | 53850 | 0 | | 1 |
| 11 | 4 | -1 | 21 | 8 | 5 | 7 | 90 | 53850 | 0 | | 1 |

Type <CR> to continue or q to quit ==>

| Row | Instance | event | chip_id | chan_id | module | adc | bco | bco_full | camac_tdc | camac_adc | INTT_even |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 5 | -1 | 21 | 120 | 5 | 3 | 90 | 53850 | 600 | | 1 |
| 11 | 6 | -1 | 21 | 5 | 5 | 2 | 90 | 53850 | | | 1 |
| 11 | 7 | -1 | 16 | 0 | 5 | 0 | 90 | 53850 | | | 1 |
| 11 | 8 | -1 | 21 | 66 | 5 | 6 | 91 | 53851 | | | 1 |
| 11 | 9 | -1 | 16 | 0 | 5 | 0 | 91 | 53851 | | | 1 |

It will effect on tracking result as the energy-weighted method is applied.

# Half-ladder assembly progress

Because of the bad HDI

Half-ladder assembly

| | Total | Good | Not yet bonded & tested | Bad |
|---|---|---|---|---|
| **Chip to HDI** | 20 | 4 | 2 | 14 |
| **Sensor to HDI** | 5 | 3 | 2 | 0 |
| **Encapsulation** | 3 | 1 | 2 | 0 |
| **Thermal cycle** | 6 | 5 | 0 | 1 |
| **On ladder** | 32 | 28 | X | 4 |

One in NWU